

Association of Periodontal Disease with Hypertension in Nigerian Patients: A Comparative Study

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Abstract

Background: Periodontal diseases are chronic and inflammatory in nature, and have been associated with hypertension, a major risk factor for cardiovascular diseases. Hypertension is prevalent among Nigerians. However, controlled studies on the relationship between hypertension and periodontal disease in Nigeria are limited. Here, we investigated the relationship between periodontal diseases and hypertension among Nigerians.

Methodology: This comparative, cross-sectional study assessed the periodontal clinical parameters, and body mass index (BMI) of 75 hypertensives and 75 gender-matched normotensive controls in a teaching hospital in Lagos, Nigeria. Hypertension was categorized as blood pressure $\geq 140/90$ mm Hg based on the WHO guidelines. Socio-demography, periodontal parameters, BMI, and blood pressure were documented in interviewer-administered questionnaires. Periodontal disease was assessed by the highest Community Periodontal Index (CPI) scores, CPI sextants, gingival index (GI), simplified oral hygiene index (OHIS), and number of teeth with gingival recession. Hypertension was the dependent variable, while periodontal disease, obesity, age were the independent variables. P values <0.05 were considered statistically significant.

Results: The mean CPI 3 sextant was significantly associated with hypertension ($P < 0.05$). The independent predictors of hypertension were moderate gingival inflammation (OR 3.314, 95% CI 1.156-9.502, $p=0.026$), older age >60 years (OR 11.527, 95%CI 2.976-44.651, $P < 0.001$), overweight/obesity (OR 3.279, 95%CI 1.414-7.602, $P=0.006$), and lower education (OR 3.070, 95% CI 1.288-7.319, $P=0.011$).

Conclusion: In addition to the known risk factors for hypertension, moderate gingivitis was a predictor of hypertension, while hypertensives had a greater extent of pockets than non-hypertensives. This study reiterates the association of preventable, low-grade periodontal inflammation with hypertension.

Keywords: Hypertension; Gingival Inflammation; Periodontitis; Community Periodontal Index; Nigeria.

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Introduction

Periodontitis is a chronic inflammatory disease characterized by the irreversible destruction of the tooth supporting tissues, due to the complex interplay between microorganisms and host immune factors.^[1] It presents with loss of periodontal tissue attachment, pathological periodontal pockets, tooth mobility and ultimately tooth loss. Periodontitis contributes immensely to the global burden of chronic diseases. Periodontitis is very common in Nigeria with prevalence rates ranging between 39% and 57%.^[2,3]

Periodontitis has been identified as a novel and potentially modifiable risk factor for cardiovascular diseases (CVD).^[4] One of the leading causes of CVD is hypertension, which has been recently linked with periodontitis. The prevalence of hypertension in Nigeria is high and varies between 27.5% and 55% depending on the American College of Cardiology /American Heart Association (ACC/AHA) 2017 guideline and the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7) 2003 guidelines respectively.^[5] The aetiology of hypertension is complex and recent evidence has suggested a possible role of inflammation in the development of hypertension.^[6]

An association has been proposed between periodontitis and hypertension and this has been attributed to endothelial dysfunction, which plays an important role in the genesis of hypertension.^[7-9] Limited data exist on the interaction between periodontitis and hypertension in Nigeria. A previous study found a relationship between periodontitis and self-reported hypertension among an adult Nigerian population.^[2] More recently, elevated serum C-reactive protein (CRP) levels were associated with increased severity of periodontitis among hypertensive patients in Nigeria.^[10] Periodontitis is preventable through the effective management of gingivitis. The huge burden of both chronic conditions (hypertension and periodontitis) in Nigeria merits further investigation, as they could predict morbidity and mortality from CVD. Limited health insurance coverage among Nigerians further complicates the ability of patients to control hypertension. This study aimed to determine the relationship between

periodontitis and hypertension among hypertensives and compare with a non-hypertensive control group in a teaching hospital in Lagos, Nigeria.

Methodology

The study was a comparative cross-sectional in design and enrolled 150 participants which included 75 with hypertension and 75 gender-matched controls without hypertension. Participants with hypertension were recruited from the hypertension clinic of the Lagos State University Teaching Hospital, a tertiary hospital in the South-west geopolitical zone of Nigeria, and a major referral center for patients who require specialist care. The controls were healthy administrative staff working within the same institution. The inclusion criteria were patients diagnosed with hypertension for at least one year, who are attending the hypertension clinic while the exclusion criteria were pregnant patients, patients with concomitant diabetes, those who had received periodontal treatment in the preceding 6 months, or prolonged antibiotic usage for over 6 months.

A convenience sampling technique was utilized. The data collection was done for a period of four months (April to October 2018). Interviewer-administered questionnaires and periodontal examination were the tools used to collect data by a single trained examiner (dentist). Data included information on socio-demographic variables, past medical history, and periodontal clinical parameters. The blood pressure of participants was measured using a digital sphygmomanometer (Omron brand). Hypertension was defined as systolic blood pressure (BP) of ≥ 140 mmHg and diastolic was BP of ≥ 90 mmHg according to the World Health Organization (WHO) guidelines.^[11] Periodontal parameters that were assessed included the Community Periodontal Index (CPI), Gingival index (GI), Simplified oral hygiene index (OHIS), and the number of teeth with gingival recession.

The WHO periodontal probe was used to assess the periodontal parameters. The prevalence of periodontal diseases was determined by the highest CPI codes per participant (CPI codes 0, 1, 2, 3) in which:

Code 0: represented healthy periodontal tissue.

- Code 1: gingival bleeding on probing.
 Code 2: calculus or other plaque retentive factors.
 Code 3: Pathological pocket of 4-5mm, in which the black band of the probe is on the gingival margin.
 Code 4: Pathological pocket of ≥ 6 mm in which the black band of the CPITN probe not visible.
 Codes X represented edentate or excluded sextants.

The prevalence of periodontitis was determined by the number and percentages of participants who scored codes 3 and 4 as their highest CPI scores. The severity of periodontal disease was determined by the mean number of sextants (MNS) per participant. The mean number of sextants for each code was calculated by dividing the total number of sextants with scores 0, 1,2,3,4, or X by the number of participants. The mean number of sextants per group was determined by dividing the total number of CPI scores by the number of participants per group. The teeth with gingival recession were categorized into ≤ 4 and >5 based on the mean number of teeth.

Approval for the study was obtained from the Research and Ethics Committee of the Lagos State University Teaching Hospital, while written informed consent was taken from the participants.

Statistical Analysis

Data analysis was achieved using Statistical Product and Service Solution (SPSS) (IBM version 27). Descriptive statistics were used in presenting the categorical variables as frequencies and percentages, while means and standard deviation using student t-test were computed for continuous variables such as age. Differences between the two groups were compared in bivariate analysis using the Chi-square test for categorical variables (Fishers where appropriate) and ANOVA for the continuous variables including age, blood pressure and gingival index. Logistic regression was used to determine the independent factors that were predictive of hypertension. P values < 0.05 were deemed as being statistically significant.

Results

Patient and Baseline Socio-demographic characteristics

Hypertensive cases and non-hypertensive controls in this study were matched for gender. The age of the study participants ranged between 23 to 77 years

with a mean age of 50.5 ± 13.8 years. Cases with hypertension had a higher mean age (58.1 ± 12.5 years) than the controls (42.9 ± 10.6 years) ($P < 0.001$). About two-thirds of the participants (63.3%) were females. Only 1.3% of the participants were smokers. The mean systolic blood pressure (SBP) was statistically significantly higher in patients with hypertension (137.7 ± 27.8 mmHg) than in the non-hypertensives (122.7 ± 7.5 mmHg) ($P < 0.0001$). The mean diastolic blood pressure (DBP) was statistically significantly higher in hypertensives (85.3 ± 20.6 mmHg) than in the non-hypertensives (76.9 ± 7.0 mmHg) ($P < 0.001$). More of the hypertensives were overweight (41.3% versus 28%) and obese (17.3% versus 2.7%) than the non-hypertensives ($P < 0.001$), while less of the hypertensives had tertiary education (33.3%) than the non-hypertensives (66.6%, $P < 0.001$) (Table 1). The most frequent mode of payment was by out-of-pocket mode for the majority of the participants (74%), followed by family support (20%) (Figure 1).

Concerning the average monthly income of the study population, 77(51.3%) claimed they earned $< \text{N}50,000$; 49(32.7%) earned $\text{N}50,000\text{-N}100,000$; 21(14%) earned $> \text{N}100,000\text{-N}250,000$, while 3(2%) earned $> \text{N}250,000$. (Not shown on a table).

Periodontal Clinical parameters

The oral hygiene status was fair in most of the participants 85(56.7%), good in 40(26.7%), and poor in 25(16.6%). More of the hypertensive patients (18.6% versus 14.6%) had poor oral hygiene, but this was not statistically significant ($P=0.505$). The majority 104(69.3%) of participants had mild gingival inflammation, while 36(24%) had moderate gingival inflammation. The severity of gingival inflammation was significantly associated with the presence of hypertension as more hypertensive participants 29(38.7%) had moderate gingival inflammation, compared to the non-hypertensives 7(9.3%) ($P < 0.001$) (Table 2). The mean gingival index was 1.02 ± 0.38 in hypertensives and 0.59 ± 0.39 in non-hypertensives ($P < 0.001$). The mean gingival index in age groups (21-40 years, 41-60 years, and >60 years were 0.49 ± 0.34 , 0.85 ± 0.42 , and 1.1 ± 0.38 respectively) and this was statistically significant. ($P < 0.0001$) CPI code 2 was the most prevalent periodontal

disease 118(78%) (Figure 2). More than 10(13.3%) of the participants with hypertension had a CPI score of 3 compared to those without hypertension 1(1.3%) (P=0.002). The mean number of CPI score 3 sextants (shallow pockets 4-5 mm) was higher in hypertensives (0.24±0.63) compared with non-hypertensives (0.01±0.12) (P=0.001). (Table 4).

Gingival recession affecting at least one tooth was observed in 60(40%) of the study population. The mean number of teeth with gingival recession was 4.2±7.3. There was no significant association between the mean number of teeth with gingival recession and hypertension (P=0.628). The effect of the antihypertensive medications (calcium channel blockers, CCB) on the gingiva was adjusted for by stratification analysis. About fifty-seven 57.3% of the hypertensives were on CCB (amlodipine/nifedipine). Although the proportion of participants on CCB who had moderate gingival inflammation was higher (41.9%, n=18) than those not on CCB (37.4%, n=11), the association was not statistically significant (P=0.675). Thus, CCB had no significant effect on the gingival index.

Following a logistic regression analysis, some sociodemographic characteristics (older age, overweight/obesity, lower education) and moderate gingivitis were independent predictors of hypertension (P<0.05) (Table 3).

Table 1: Bivariate analysis between socio-demographic variables and hypertension

Variables	Hypertensive N (%)	Non-hypertensive N (%)	Total	X ²	P-value
Age group (years)					
21-40	7(9.3)	33(44.0)	40(26.7)	38.591	<0.001*
41-60	34(45.3)	37(49.3)	71(47.3)		
>60	34(45.3)	5(6.7)	39(26.0)		
Gender				0.258	0.735
Male	26(34.7)	29(38.7)	55(36.7)		
Female	49(65.3)	46(61.3)	95(63.3)		
Smoking status				2.027	0.497
Smoker	2(2.7)	0(0.0)	2(1.3)		
Non-smoker	73(97.3)	75(100)	148(98.7)		
BMI class				15.571	<0.001*
Underweight	2(2.7)	4(5.3)	6(4.0)		
Normal weight	29(38.7)	48(64.0)	77(51.3)		
Overweight	31(41.3)	21(28.0)	52(34.7)		
Obesity	13(17.3)	2(2.7)	15(10.0)		
Level of education				20.888	<0.001*
None	5(6.7)	2(2.7)	7(4.7)		
Primary	14(18.7)	2(2.7)	16(10.7)		
Secondary	31(41.3)	21(28.0)	52(34.6)		
Tertiary	25(33.3)	50(66.6)	75(50.0)		

*Significant

Table 2: Bivariate analysis between oral hygiene, periodontal parameters and hypertension

Variables	Hypertensive N=75 N (%)	Non-hypertensive N=75 N (%)	Total N=150 N (%)	X ²	P-value
Oral hygiene status				1.366	0.505
Good	17(22.7)	23(30.7)	40(26.7)		
Fair	44(58.7)	41(54.7)	85(56.7)		
Poor	14(18.6)	11(14.6)	25(16.6)		
Gingival health status				24.829	<0.001*
Good	0(0.0)	10(13.3)	10(6.7)		
Mild	46(61.3)	58(77.3)	104(69.3)		
Moderate	29(38.7)	7(9.3)	36(24.0)		
Highest CPI scores				9.886	0.002*
CPI 0	4(5.3)	13(17.3)	17(11.3)		
CPI 1	2(2.7)	3(4.0)	5(3.3)		
CPI 2	59(78.7)	58(77.3)	117(78.0)		
CPI 3	10(13.3)	1(1.3)	11(7.3)		
Treatment Needs (TN)				5.774	0.051
TN 0	4(5.3)	13(17.3)	17(11.3)		
TN 1	2(2.7)	3(4.0)	5(3.3)		
TN 2	69(92)	59(78.7)	128(85.3)		
Teeth with gingival recession (n=60)				0.234	0.628
-	12(30)	8(40)	20(33.3)		
.	28(70)	12(60)	40(66.7)		

*Significant

Table 3: Extent of periodontitis by Mean Number of CPI sextants

Mean No. of CPI sextants	Hypertensive N=75	Non-hypertensive N=75	Total Mean	t-test
0	1.23±1.60	1.95±2.28	1.59±1.99	0.027*
1	0.32±1.04	0.31±1.05	0.31±1.04	0.938
2	4.19±1.81	3.73±2.32	3.96±2.09	0.185
3	0.23±0.63	0.01±0.12	0.12±0.46	0.004*

*Significant

Table 4: Logistic regression analysis of independent predictors of hypertension among Subjects in the Medical Outpatient clinics

Predictors	AOR	95% CI	P-value
Age group (years)			
21-40	1		
41-60	2.064	0.710-5.998	0.183
>60	11.527	2.976-44.651	<0.001*
BMI class			
Underweight/Normal weight	1		
Overweight/Obese	3.279	1.414-7.602	0.006*
Level of education			
Tertiary	1		
-	3.070	1.288-7.319	0.011*
Gingival Inflammation			
Good/Mild	1		
Moderate	3.314	1.156-9.502	0.026*
Prevalence of periodontal disease			
HighestCPI 0,1,2	1		
Highest CPI 3	5.270	0.527-52.693	0.157

*Significant AOR=Adjusted odd ratio

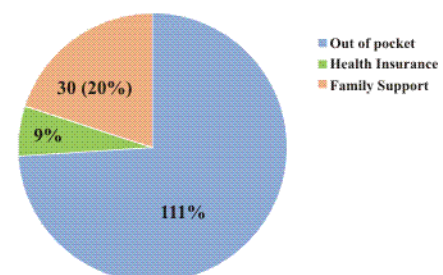
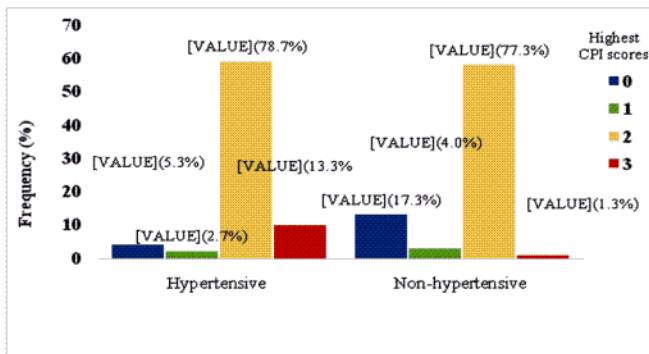


Figure 1: Frequent mode of payment for medical treatment

Figure 2: Prevalence of periodontal disease

Discussion

To the best of the authors' knowledge, this is the first published study in Nigeria to compare the periodontal status of hypertensives with a non-hypertensive control group. We assessed 75 patients with hypertension and 75 healthy volunteers. Our findings revealed that hypertension was independently associated with moderate gingivitis (OR=3.314, 95% CI: 1.156-9.502, P=0.026) but also with older age (OR=11.527, 95% CI: 2.976-44.651), p<0.001, overweight/obesity (OR=3.279, 95% CI: 1.414-7.602, P=0.006), and lower education (OR=3.070 95%CI: 1.288-7.319, P=0.011). The odds of having hypertension was three times higher in patients with moderate gingivitis compared to those with mild gingivitis or healthy gingiva after adjusting for confounding factors such as age, overweight/obesity, and educational level. In addition, the mean CPI 3 sextants (shallow pockets) was significantly higher in hypertensives (0.23) than non-hypertensives (0.01) (P<0.01), while the mean CPI 0 sextants (healthy) was significantly higher in non-hypertensives (1.23) than hypertensives (1.95) (P<0.05).

A growing body of evidence has established an association between severe periodontitis and cardiovascular diseases (CVD).^[12] Some of the mechanisms proposed include bacteraemia through the ulcerated periodontal pocket epithelium. This subsequently activates the liver acute phase proteins, the CRP which become elevated and amplify the systemic inflammatory burden, thus promoting atherogenesis.^[13] More recently, the relationship between periodontal status and hypertension is being explored. Hypertension remains the major risk factor for CVD and an

important driver of the global disease burden.

In the current study, we utilized the CPITN to assess periodontal disease in the study participants because of its simplicity, speed, cost-effectiveness, and convenience as the periodontal evaluations were performed in the medical outpatient clinic, instead of, the dental setting. We are cognizant of the limitations of the CPITN being a partial mouth recording index that can overestimate or underestimate periodontal disease due to its scoring system.^[14] This is particularly true when the highest/worst CPI score is used alone, and is thus less sensitive.^[14] Exploring the CPI sextants is useful in assessing the extent and severity of pockets, and therefore, determined this in the present study. The significantly higher mean number of CPI 3 sextants (shallow pockets, 4-5 mm) observed in hypertensives in the current study indicates a greater severity of periodontitis than in the control group. This is in agreement with other studies that found more attachment loss in hypertensives.^[8,15-17] The association between periodontal parameters and elevated arterial blood pressure was also documented in a case-control study in Senegalese patients.^[17] Periodontitis was significantly associated with hypertension after adjustment for physical inactivity, heredity, age, age-periodontitis interaction and other periodontal parameters and the CPITN was higher in hypertensives (2.5±0.998) than the non-hypertensive control group (1.2±1.074).^[17] Acute periodontal inflammation assessed by periodontal inflamed surface area (PISA) and bleeding on probing (BOP) was also observed in association with high blood pressure, independent of periodontitis parameters.^[18]

The association between hypertension and periodontitis is biologically plausible as both conditions have an inflammatory basis.^[8,19] The significant contribution of periodontal disease to systemic inflammatory burden,^[11] may amplify the effect/role of inflammation in the pathogenesis of hypertension, and propagate the periodontal-hypertension link.^[6,20]

Scientific evidence through clinical and experimental research suggests that hypertension could cause microcirculatory changes in the gingival tissue, leading to ischaemia, increased

inflammation, and/or altered microbial composition of the dental biofilm.^[8] Arowojolu and Colleagues found no association between the worst CPI score (periodontitis) and high blood pressure among Nigerians.^[21] Although the authors determined the mean CPI sextant score in their study, they had no control group for comparison.

In our study, moderate gingivitis was also independently associated with hypertension. A recent cross-sectional survey utilizing the National Health and Nutrition Examination Survey (NHANES) III data among 5396 adults of at least 30 years old, also found gingivitis was consistently associated with increased risk of high/uncontrolled BP.^[15] A significant relationship was also observed between an increase in blood pressure (BP) and gingival status, oral hygiene, and increasing age.^[21] The current study utilized the gingival index by Silness and Loe to assess gingival status.^[22] Moderate gingival inflammation is characterized by redness, edema, and bleeding on probing (BOP). Bleeding gums, which are features of biofilm-induced gingival low-grade inflammation are recognized and crucial signs of oral inflammation with the systemic effect mediated by inflammatory biomarkers. Emerging evidence suggests that the contained gingivitis lesion may have systemic inflammatory consequences.^[23-25]

To further determine the potential effect of medications such as amlodipine/nifedipine that could cause gingival enlargement,^[26] we had adjusted for this factor and found no association between the type of medication used by the participants' and their gingival index.

Thus, the relationship between BOP and hypertension may reflect acute pathogenesis of inflammation, which might be efficiently extended into systemic effects.^[18] Although, the current study was limited in that it did not assess any inflammatory biomarkers, others have reported increased CRP levels in association with periodontitis,^[16] however it has also been documented in relation to the mean gingival index.^[27] In a recently published Nigerian study, an association was reported between serum CRP levels and the severity of periodontitis among hypertensive patients.^[10] Our study findings should

be interpreted with some caution as this was a cross-sectional study by design, and cannot establish a cause and effect relationship.

Advancing age is a well-recognized risk factor for hypertension as stated by the WHO.^[11] Our study findings corroborated this and is similar to that of a recent, epidemiological Chinese study, which found an association between older age and blood pressure in 3.3 million participants, aged 35-75 years from 31 provinces.^[28] This phenomenon affects populations globally, and is attributed to the reduced elasticity of the blood vessels with ageing.

Low education was also found to be a predictor of hypertension in the current study. Naturally, the older population in Nigeria, above 60 years of age are most likely to be secondary school certificate holders, and less educated. This may negatively impact on their knowledge and practice of preventive measures, such as physical exercise. This association was also reported recently in the Chinese study.^[28] There was a statistically significant association between BMI and hypertension in this present study which is in tandem with the study by Landi et al, where they found BMI was an independent strong risk factor for hypertension.^[29] The participants were assessed during the Longevity Check-up 7+ (Lookup 7+) project.

Multifaceted preventive strategies therefore, should be implemented to address the barriers at different levels.^[30] It is noteworthy that gingivitis is a necessary pre-requisite, for periodontitis. Its management, is thus, a primary prevention strategy for periodontitis.^[24] This underscores the importance of early detection of early periodontal inflammatory disease as a targeted prevention aid in reducing the risk of hypertension. Overall, our findings suggest that gingivitis and moderate periodontitis are associated with hypertension among Nigerians. Our study had some limitations and as such our findings should be interpreted with some caution. The control group was not age matched with the cases (hypertension). However, we addressed this in our statistical analysis by applying logistic regression to control for its potential influence on the outcome. Also, the use of partial periodontal recording in the present study instead of a full mouth periodontal

assessment could have underestimated/overestimated the prevalence of the periodontal disease. The presence of inflammatory biomarkers was also not assessed in the study and could have provided more measures of systemic inflammation from the periodontal disease. Being a cross-sectional analytic study, a cause and effect between periodontal disease and hypertension could not be established. The strength of our study however is the inclusion of a comparative control group and the adjustment of the confounding factors. By this study, we have provided some data on the association between biofilm-induced periodontal disease and hypertension in the Nigerian population. This can serve as a basis for future longitudinal studies with larger sample sizes to further elucidate our findings utilizing inflammatory biomarkers.

In conclusion, the present study has demonstrated that moderate gingivitis, is a risk factor for hypertension, while moderate periodontitis in form of shallow pockets is associated with hypertension among Nigerians. Early screening and detection of periodontal disease at early stages is instrumental for planning appropriate periodontal interventions which may potentially reduce the blood pressure levels in patients. This is particularly important in resource-restricted settings such as Nigeria where the cost of treating hypertension is prohibitive and mostly funded by out-of-pocket expenditure as observed in the present study where the monthly income of more than half of the participants was less than N50,000.

We recommend further elucidation of larger multicenter studies among hypertensives and suitable controls to elucidate these findings. Regular and rapid screening of hypertensives should be done to detect early signs of periodontal disease and explore the effect of oral prophylaxis on blood pressure levels and overall systemic health in Nigerians.

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